1.0 Introduction

The purpose of this memorandum is to document the procedures used to develop the base year highway network for the Southwest Georgia Interstate model. The Southwest Georgia Interstate model network represents the roadway system within the study area used in the assignment of the travel demand. The results from the traffic assignment are used to summarize the travel patterns among the different geographic areas and to determine whether the operating conditions of the facilities warrant roadway improvements. The base year roadway network was built from the Federal Highway Administration's (FHWA) National Highway Planning Network (NHPN) version 4.0. The NHPN network contains roadway data for all 50 States, including the District of Columbia, and Puerto Rico. It was modified to meet the network requirements for the Southwest Interstate Georgia model. The majority of the roadway links outside the five (5) southeastern states is not necessary for the model application and can be eliminated. This reduces the computational burden during a model run without sacrificing the accuracy and integrity of the model results. The network was built such that the network details gradually decrease as it expands out from the southwest Georgia study area to the rest of the nation. Except for the five (5) southeastern states, the roadway network is kept at the Interstate highway system level. For the buffer region between the southwest Georgia study area the outlying states, the network includes both Interstates plus state routes. Since the model is focused on the southwest Georgia study area, the network links within the study area are represented in greater detail which includes all the functional classified roadways. The current GDOT RC roadway network was used to validate all of the links within Georgia and to verify the NHPN links' connectivity, number of lanes, and functional class. Most of network cleaning work and editing was performed inside the ArcGIS software. The final network was then converted into the CUBE software format in which the centroids and centroid connectors were added. Additional centroids and connectors were added to represent travel between the U.S. and the neighboring counties of Canada and Mexico. The final network covers all of the continental U.S. with 1,569 centroids and 82,360 miles of roadways.

1.1 National Highway Planning Network

The National Highway Planning Network (NHPN) is the primary data source for the Southwest Interstate network. This network contains all U.S. States, including District of Columbia and Puerto Rico. However, only the roadways within the 48 states and District of Columbia were used as the network base. Figure 1.1.1 shows the extent of the existing NHPN used to build the Southwest Interstate network. Since the southwest Georgia network is primarily focused on the state of Georgia region with an emphasis on the southwest Georgia study area, details in the roadway network are less important outside Georgia. On the other hand, the closer the region to the southwest Georgia study area is, the more detail in the roadway network is required. Consequently, a 5-layered system for the network was created as listed below depending on the network regions. The layered system is designed in a way in which the details in the highway network diminish as it expands out from the heartland of the study area to the rest of the country.

- Southwest Georgia study area region (the 32 counties inside the study area)
- The rest of Georgia region (the rest of 127 Georgia counties)
- 50-mile Georgia border surrounding buffer region (including portions of the five (5) southeastern U.S. states of Alabama, Florida, North Carolina, South Carolina, and Tennessee)
- The rest of the five (5) southeastern states
- Outlying states (the rest of the 43 states plus District of Columbia)

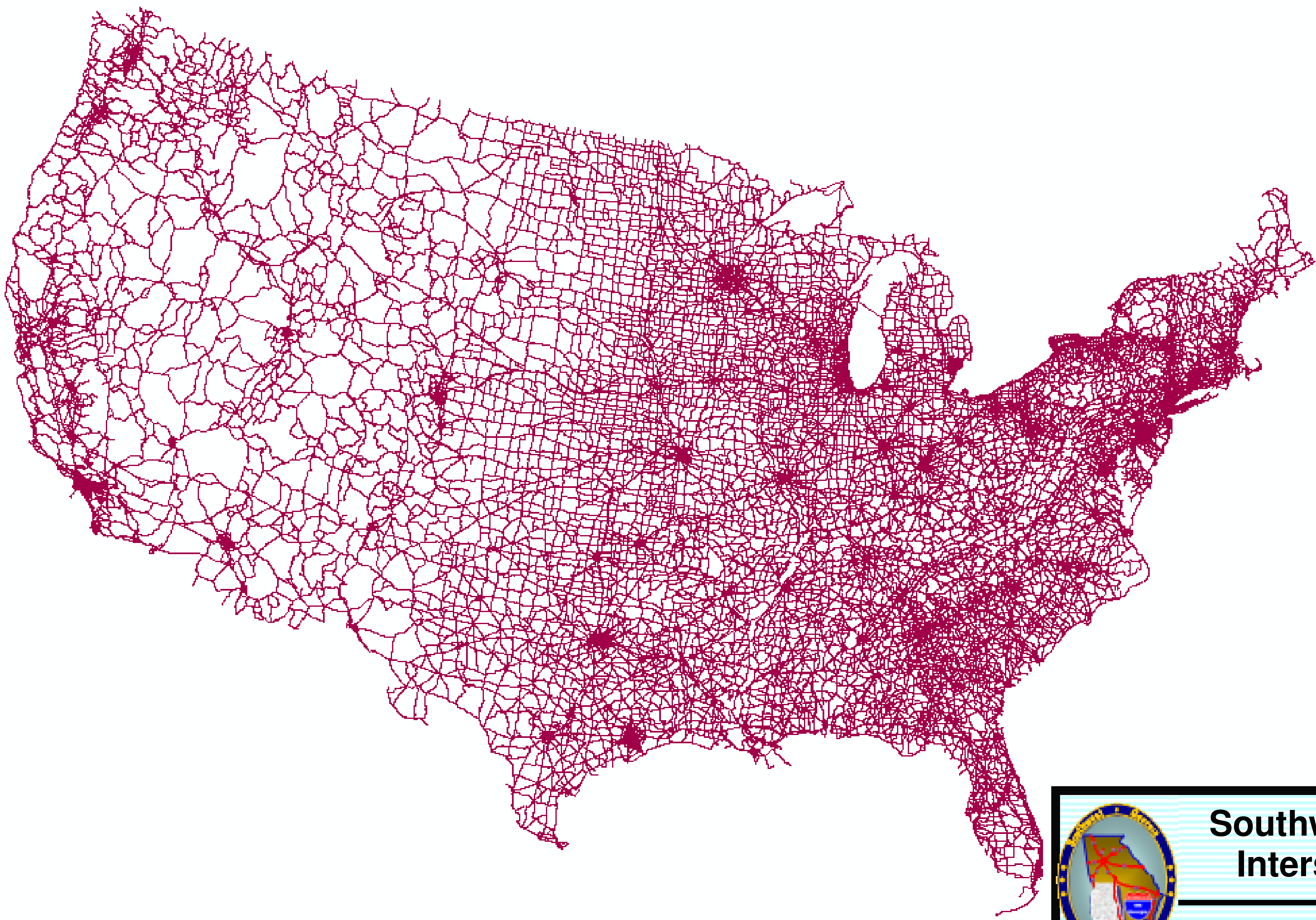
The NHPN includes all Interstates, state routes, some arterials, and few collector roadways in every state. The roadway classifications available in the NHPN are shown in Table 1.1.1. This classification system is consistent with the Highway Performance Monitoring System (HPMS). However, the functional classifications are only reliable at the Interstate and Principal Arterial levels, and many of the roadway links below the Arterial level are not well represented in NHPN.

Within the southwest Georgia study area, the network must include all functional classified roadways plus some local roads that are considered important to provide connectivity and access. Missing roadway links within the study area were checked and added back to NHPN. In the outlying states, only the major Interstate routes were kept while any non-Interstate network links were eliminated. Using only interstate highways in the outlaying states allows the analysis of national travel patterns, and is considered especially useful in the freight movement assignment. Doing so, interstate travel across the southwest Georgia region can be accurately modeled. On the other hand, the elimination of the non-interstate highways in those states has little impact on the southwest Georgia region and can significantly reduce the model run time. Between the study area and the outlying states, there are three network layers: the rest of the Georgia counties, the 50-mile buffer zone surrounding the Georgia border, and the rest of the five (5) southeastern states. The network links within the 50-mile buffer zone include all of the existing NHPN links, and the network links in the rest of the five (5) southeastern states include only the Interstates and major state routes. For the rest of the Georgia counties, all roadways from the NHPN were included and checked against the GDOT RC file. This design of the network system significantly reduces the amount of unnecessary network links, reducing the required computer running time without sacrificing model accuracy. It also lays out a sound network foundation so that further expansion to a statewide model network becomes possible.

Table 1.1.1
NHPN Functional Classes

Functional Class	Description
1	Rural Interstate
2	Rural Principal Arterial
6	Rural Minor Arterial
7	Rural Major Collector
8	Rural Minor Collector
9	Rural Local
11	Urban Interstate
12	Urban Freeway or Expressway
14	Urban Principal Arterial
16	Urban Minor Arterial
17	Urban Collector
19	Urban Local

The NHPN includes not only the existing highways but also planned and proposed ones. These roadways are either in the planning stage or under construction and do not belong to the existing infrastructure. Those roadway links were removed from the NHPN. The refined NHPN and the 5-layer system boundary are shown in Figure 1.1.2.

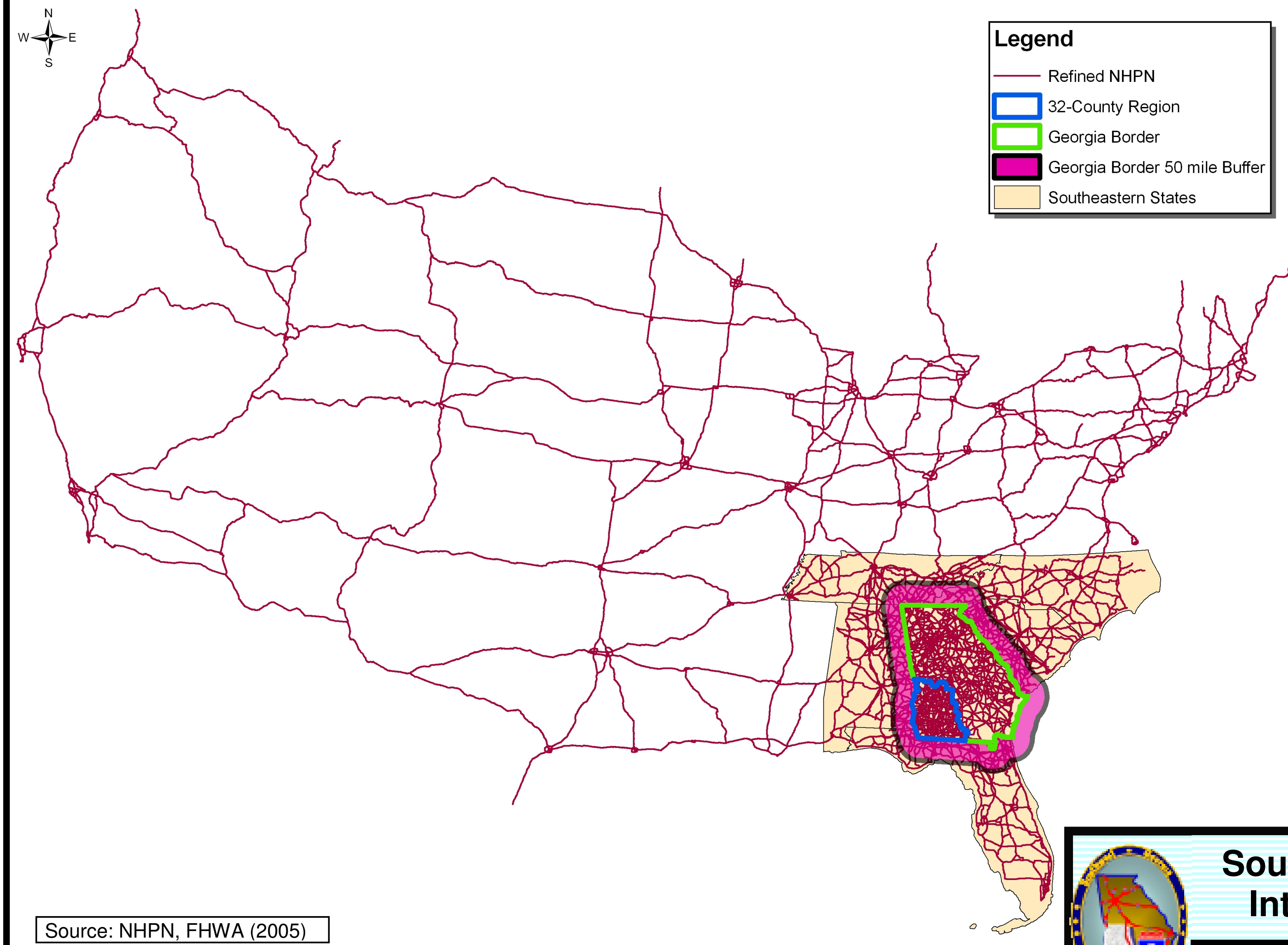


Source: NHPN, FHWA (2005)

Southwest Georgia Interstate Study

US Continental States NHPN

Network Development | **Figure 1.1.1**



Southwest Georgia Interstate Study

Refined NHPN

Network Development

Figure 1.1.2

1.2 GDOT Road Characteristic File & Network Validation

GDOT uses a Road Characteristic (RC) file to maintain and update roadway information for all functional classified roadways within the state. The roadway characteristic information of the RC file is stored in a MS Access database as an event table. The information in the table can be mapped onto a network centerline shapefile based on the RC route identifier and its associated mile post limit. The RC file contains more information on the roadway condition than that in the NHPN. In many cases, the RC file is superior to the NHPN because it is updated frequently, includes more detailed roadway information, and has a route system that can map any event data, such as accident data and planned project information. However, the roadway links and their connectivity in the RC centerline file are not in a manner that can be directly used as a base network for a travel demand model. Disconnected roadway links and mis-constructed intersections in a network can create unrealistic bottlenecks and unreasonable trip paths, skewing and misinterpreting the results of the traffic assignment. Therefore, instead of using it as a network foundation, the RC centerline file is used as a basis against which the NHPN links are validated and checked for the latest update available in the RC file.

While the RC file provides rich information about the roadway conditions, only the information about number of lanes, functional classification, and roadway geometric alignment are used to validate the southwest Georgia Interstate model network. The network validation using RC file was only performed on roadway links that are located within Georgia with the emphasis placed on the network links within the study area that requires detailed roadway representation. For NHPN network links located outside the state of Georgia, the number of lanes was verified by using the latest aerial photography available, and the roadway function classification from the NHPN was used. The current GDOT RC centerline is shown in Figure 1.2.1. The network check and validation of the network within Georgia was performed in two steps.

- Roadway alignment check
- Roadway functional classification and number of lanes validation

The foundation of a roadway system is its geometric alignment for each roadway. Since the NHPN is considered accurate at the Interstate highway and major state route levels, other roadways with lower functional classification are not well represented or simply missing. However, many of those unrepresented links are required as a part of the model network especially within the study area. Moreover, the missing links are required to establish many of the traffic analysis zone (TAZ) boundaries and provide necessary roadway access and connectivity within the study area. As shown in the Figure 1.2.2, the red links indicate the required but unrepresented roadways that exist in the RC file but not in the NHPN, while the blue links represent the existing roadway links in NHPN.

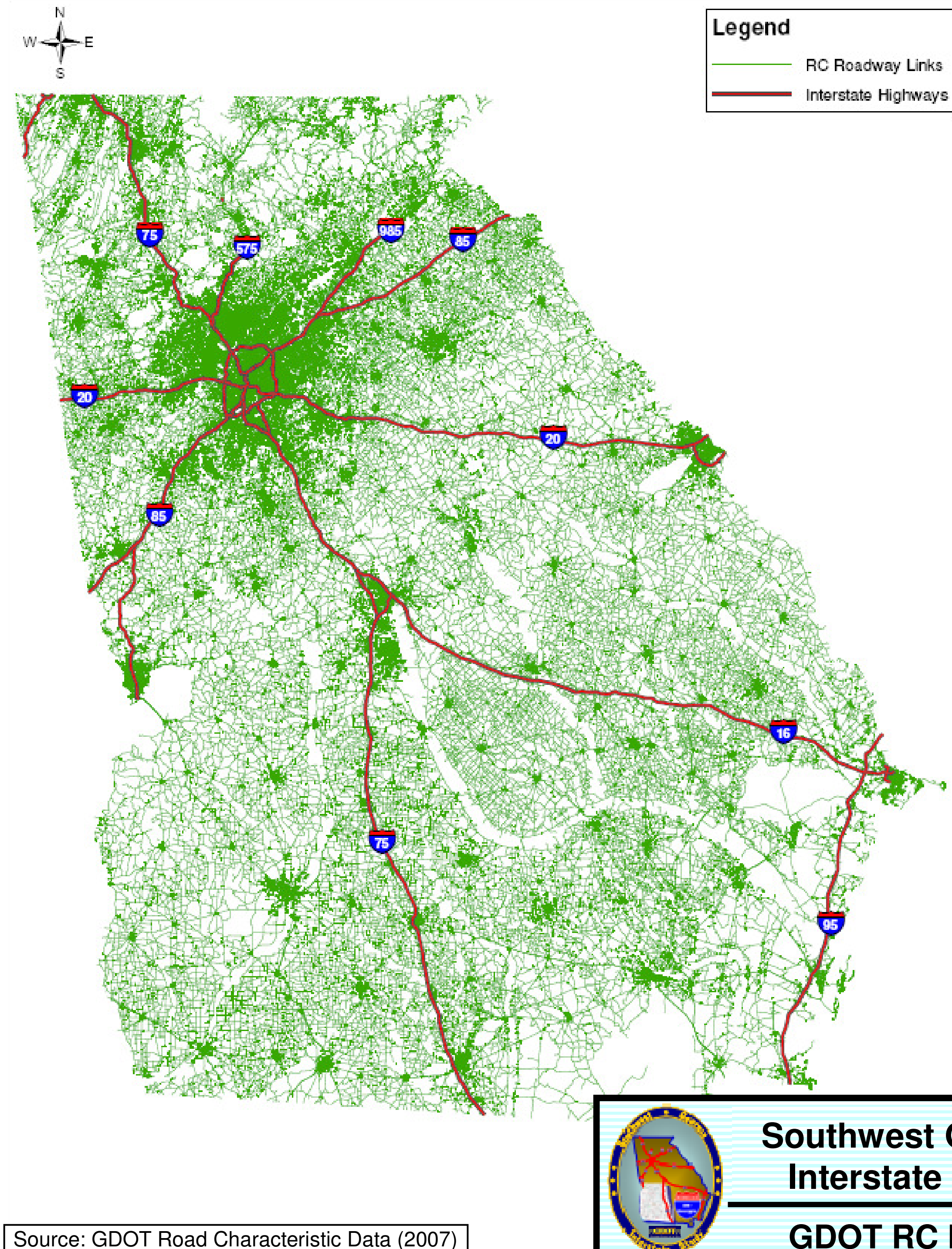
The majority of these missing roadway links belong to facilities with the functional class designation lower than arterials. These missing roadways are typical network links that are not well represented in the NHPN but required in the study area to produce a detailed traffic assignment. As a result, a detailed network edit was performed within the study area region. The missing roadway links in the NHPN were digitized according to the underling RC network alignment and the connections among the network links were verified. The link connectivity verification process included the identification of highway at-grade intersections and grade separated locations and the checking of network connectivity to ensure that the different connectivity types were represented at those locations accordingly. In addition, plots of the network by the number of lanes within the study area were also sent to the local GDOT district offices for review. The corrections were reflected in the final model network.

Roadway functional classification and the number of lanes were validated by overlaying the RC centerline with the NHPN in ArcGIS. The functional classification and number of lanes are symbolized in color for both network layers, and the overlay display facilitates the identification of mismatch links between the two networks. This step was performed to ensure that the roadway link capacity and speed correctly reflect the existing conditions, since both capacity and speed are determined by the roadway functional classes and number of lanes.

Table 1.2.1 lists the centerline mileage by layer in the final network.

Table 1.2.1
Network Mileage Status

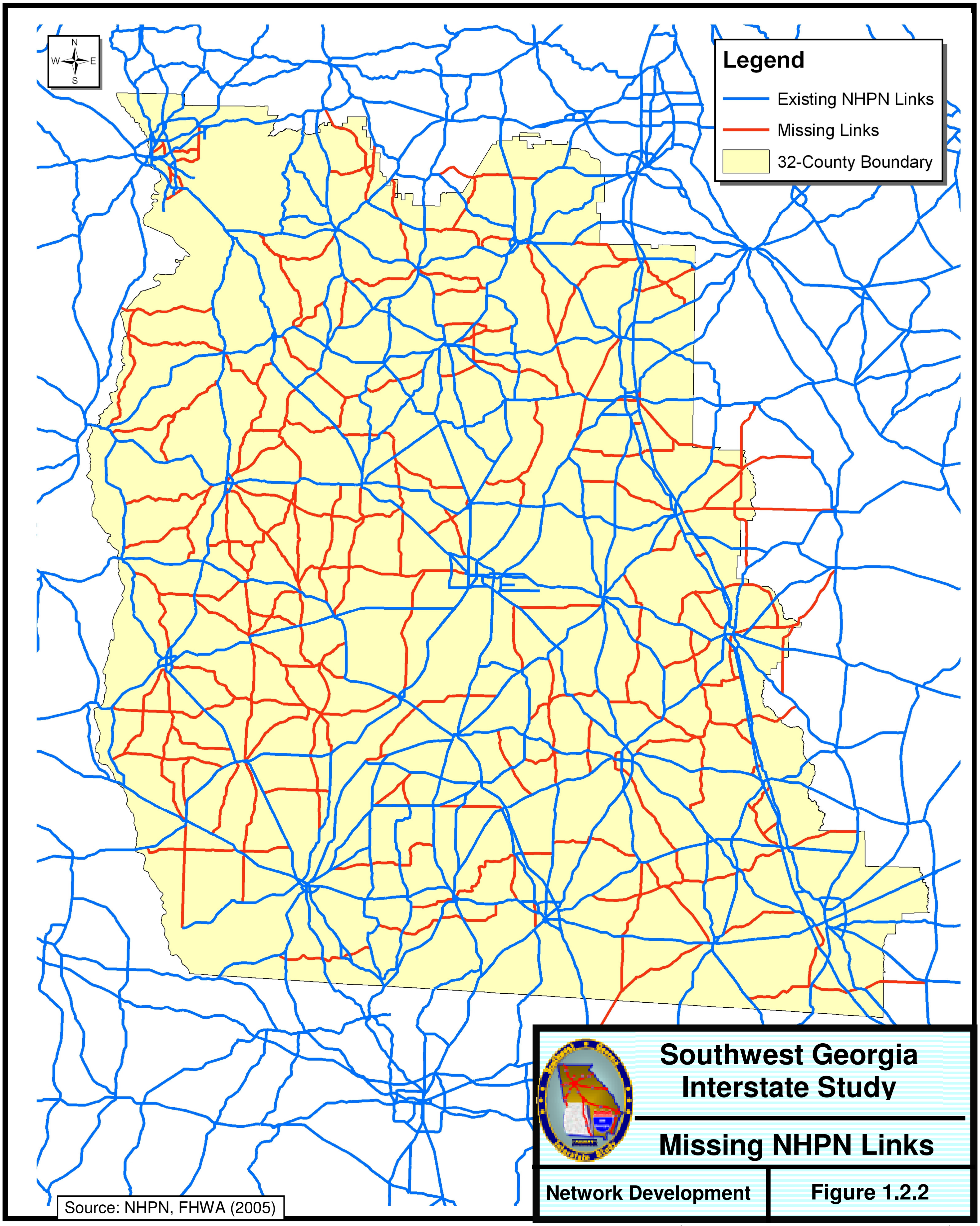
Network Region	Mileage
Southwest Georgia study area	4,800
The rest of Georgia region	13,399
50-mile Georgia border buffer region	10,441
The rest of the 5 southeastern states	17,031
Outlying states	36,689
Total	**82,360**



Southwest Georgia Interstate Study

GDOT RC Network

Network Development | Figure 1.2.1


N
W
E
S
Legend
Existing NHPN Links
Missing Links
32-County Boundary
Southwest Georgia
Interstate Study
Missing NHPN Links
Network Development
Figure 1.2.2
Source: NHPN, FHWA (2005)

1.3 Network Link Capacity & Speed

Highway network link capacities and speeds are key elements that play an essential role during the traffic assignment process. They determine the resulting levels of congestion from the assignment and therefore must be accurately reflected in the network links in order to produce meaningful results. The speed and capacity for each network link are determined by the functional classification and number of lanes of the underling roadway. The link speeds were determined based only on the roadway's functional class. There are a total of 12 functional classifications and a maximum of the 14 two-way traveled lanes observed in the network. The observed roadway functional classes and number of lanes in the network are shown in Table 1.3.1. As expected, the higher the levels of the roadway facility are, the higher the maximum number of lanes. Twelve lane highways are only available in the Urban Interstate classification, while none of the local roads has more than 4 lanes in both directions. Network link speed and capacity tables are established according to this table.

Table 1.3.1
Observed Network Functional Classes & Number of Lanes

	Number of Traveled Lanes (2-way)						
Functional Class	**2**	**4**	**6**	**8**	**10**	**12**	**14**
Rural Interstate		✔	✔	✔	✔		
Rural Principal Arterial	✔	✔	✔	✔			
Rural Minor Arterial	✔	✔	✔				
Rural Major Collector	✔	✔					
Rural Minor Collector	✔	✔					
Rural Local	✔	✔					
Urban Interstate		✔	✔	✔	✔	✔	✔
Urban Freeway/Express Way(Non-Interstate)		✔	✔	✔	✔		
Urban Principal Arterial	✔	✔	✔	✔	✔		
Urban Minor Arterial	✔	✔	✔				
Urban Collector	✔	✔					
Urban Local	✔	✔					

The 12 roadway functional classifications was aggregated into seven (7) roadway facility types based on the similarity of the classification in both urban and rural area. The aggregation is shown in Table 1.3.2. For example, the urban and rural interstate functional classifications are aggregated into an interstate facility type. In addition to the roadway facility type, three area types were also introduced into the network link based on the population density of the area in which the network link resides. The definition and implementation of the area type is discussed in detail in the *Technical Memorandum – Travel Demand Model Development*. The three area types introduced are:

- Dense Urban area (population density > 1,000 persons/square mile)
- Small Urban area (150 persons/square mile <population density <= 1,000 persons/square mile)
- Rural area (population density <=150 persons/square mile)

Table 1.3.2
Roadway Facility Types & Functional Classifications

Facility Type	Functional Class
Interstate	1, 11
Freeway/Expressway (non-interstate)	12
Principal Arterial	2, 14
Minor Arterial	6, 16
Major Collector	7, 17
Minor Collector	8
Local	9, 19

The network capacity and speed were assigned to each network link based on the roadway facility and area types. The capacity is expressed in daily vehicles per lane and link capacity can be calculated by multiplying the lane capacity by the total number of lanes available on that link. The daily capacity values were developed and refined based on the Florida Department of Transportation's (FDOT) guideline for annual average daily volumes. The daily capacity per lane for the network link based on the facility and area types is shown in Table. 1.3.3. The network link speed based on the facility and area types is shown in Table 1.3.4.

Table 1.3.3
Network Link Daily Capacity (vehicles/lane/day)

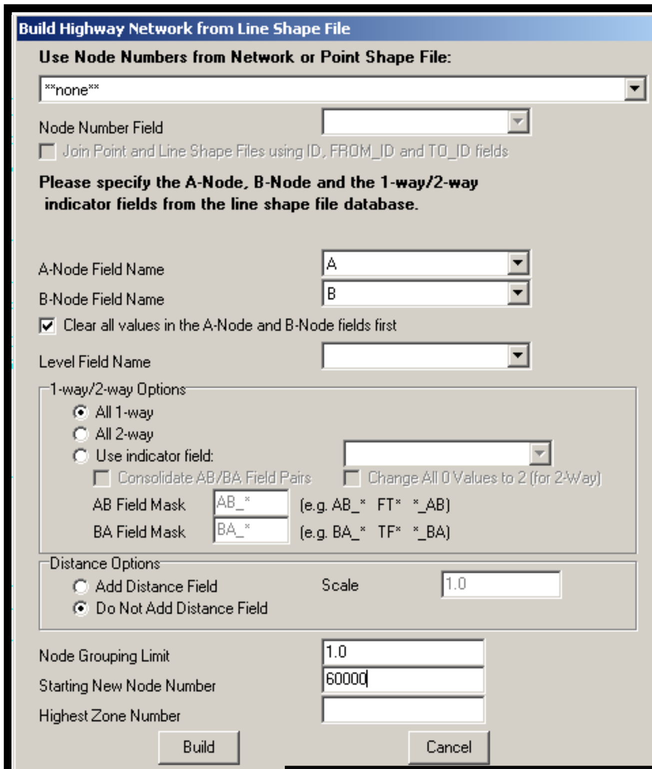
Facility Type	Dense Urban	Small Urban	Rural
Interstate	19,125	17,275	15,750
Freeway/Expressway (non-interstate)	19,125	17,275	15,750
Principal Arterial	8,450	8,150	11,150
Minor Arterial	7,750	7,650	7,450
Major Collector	6,300	6,150	7,450
Minor Collector	6,300	6,150	6,050
Local	6,300	6,150	6,050

Table 1.3.4
Network Link Speed (miles/hour)

Facility Type	MPO	Small Urban	Rural
Interstate	65	68	70
Freeway/Expressway (non-interstate)	55	60	65
Principal Arterial	45	50	60
Minor Arterial	40	45	55
Major Collector	35	40	45
Minor Collector	30	35	40
Local	20	25	30

1.4 Network Conversion & Centroid Connector Additions

The network edit and validation phases were mainly performed using the ArcGIS software in an ESRI shapefile format. This was done to take the advantage of various GIS capabilities available in the software. It was determined that the CUBE software platform would be used for the development and application of all of the model components and highway networks. The validated network shapefile can be used as a network basis on which the CUBE network can be created. The CUBE based network can be generated by using the "Build Highway Network from the Line Shape File" utility available in CUBE as shown in Figure 1.4.1. This utility allows users to create a CUBE network from a shapefile. A network shapefile is a polyline link based GIS file. A CUBE network on the other hand is a link and node based file. It is required that the shapefile contain A and B node fields in its attribute table that will be used to store the A and B node number once the network creation process in CUBE completes. Two blank fields therefore were added in the shapefile table. In addition, in the utility setup window, the "Clear all values in the A-Node and B-Node fields first" must be checked. This allows the program to assign node numbers for A and B nodes in the created CUBE network. The created CUBE network is shown in Figure 1.4.2.

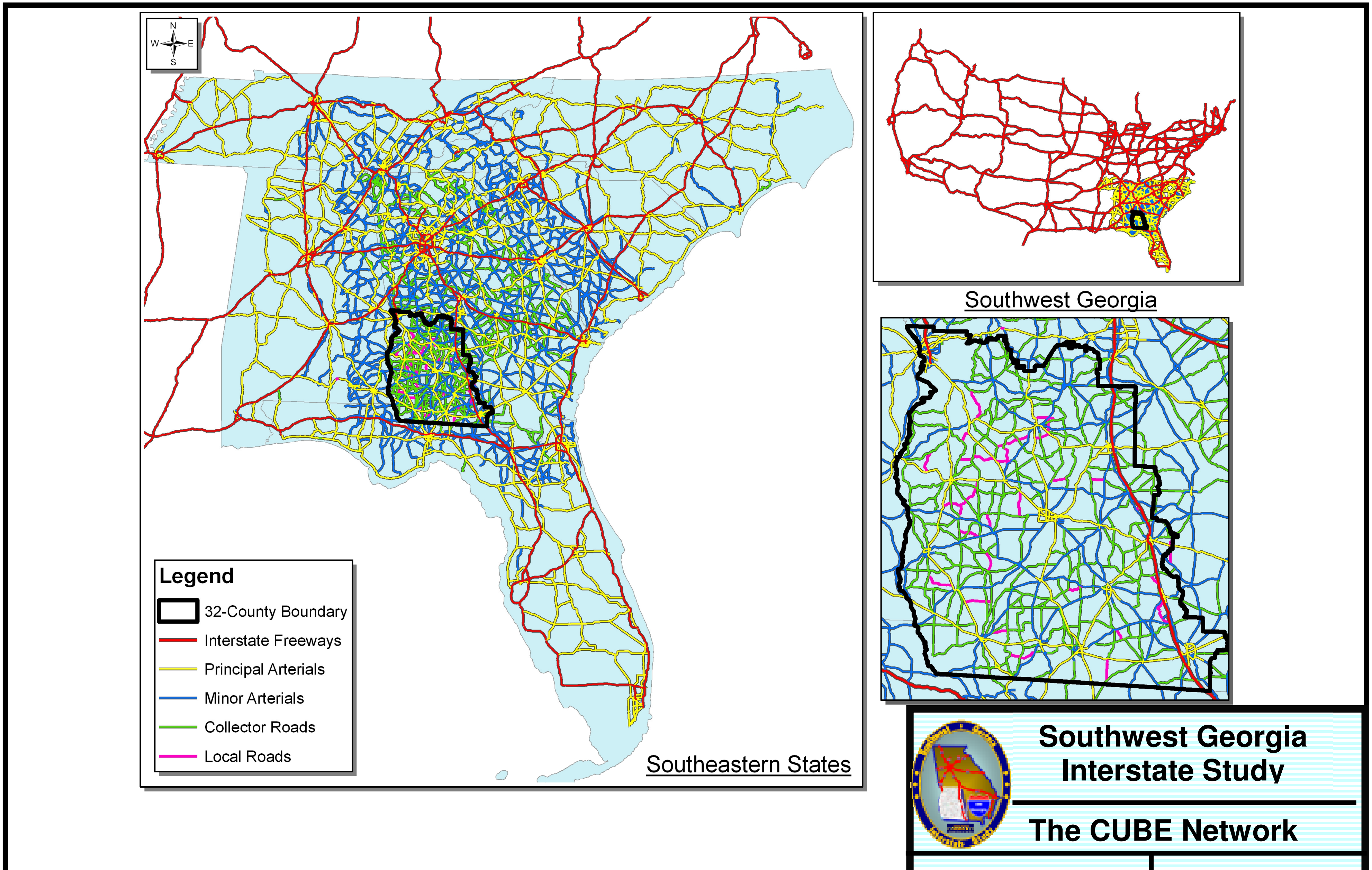


Southwest Georgia Interstate Study
Network Conversion
Network Development
Figure 1.4.1

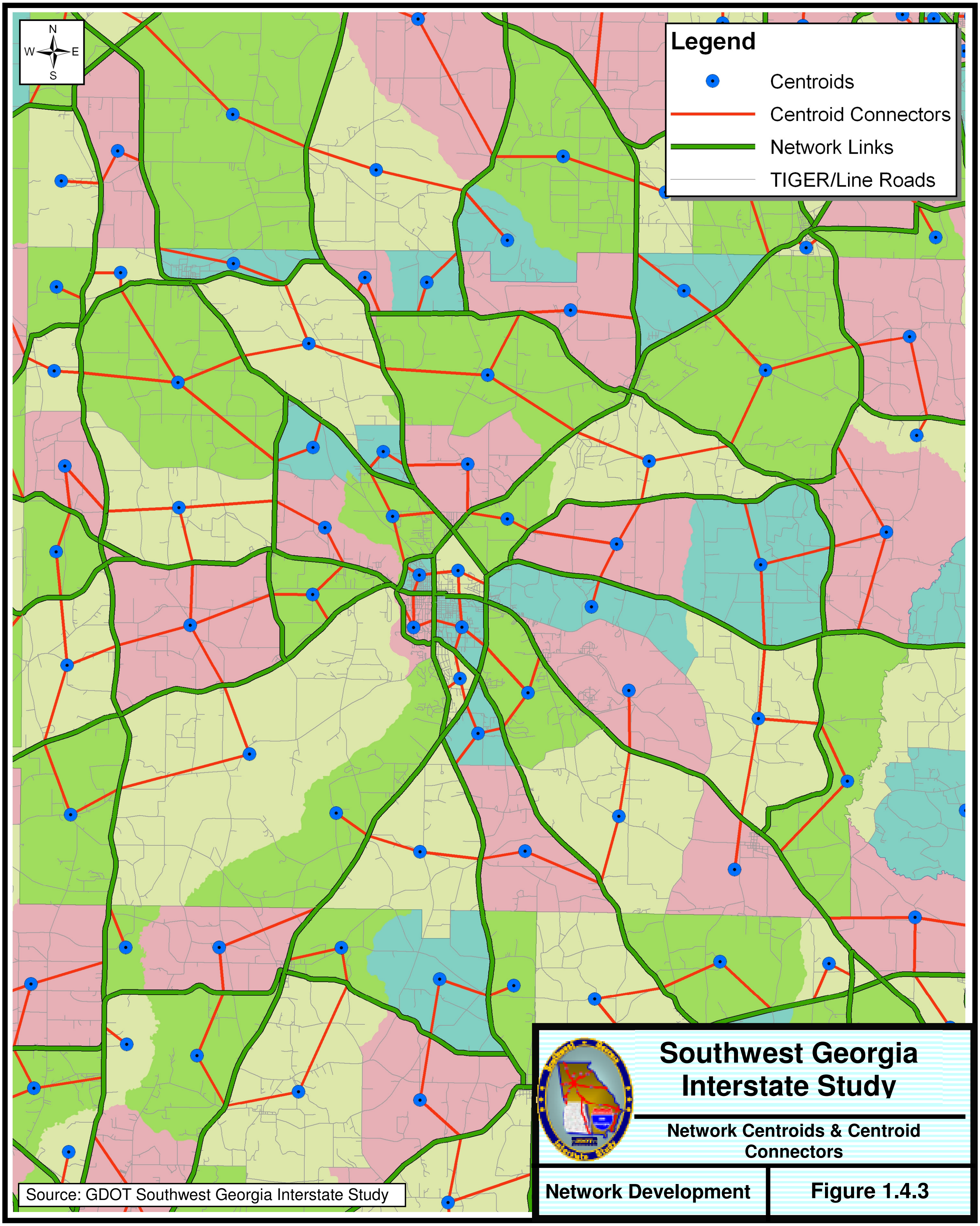
The network centroids and centroid connectors were added after the CUBE network has been created. Since the CUBE network is a link and node based network, it is a convenient process to create centroids and their centroid connectors within CUBE. The zone numbers for the centroids can be reserved during the CUBE network creation process. By setting the "Starting New Node Number" value higher than the available zone number, the network created will leave enough gap in the numbering sequence for the addition of new nodes for centroids.

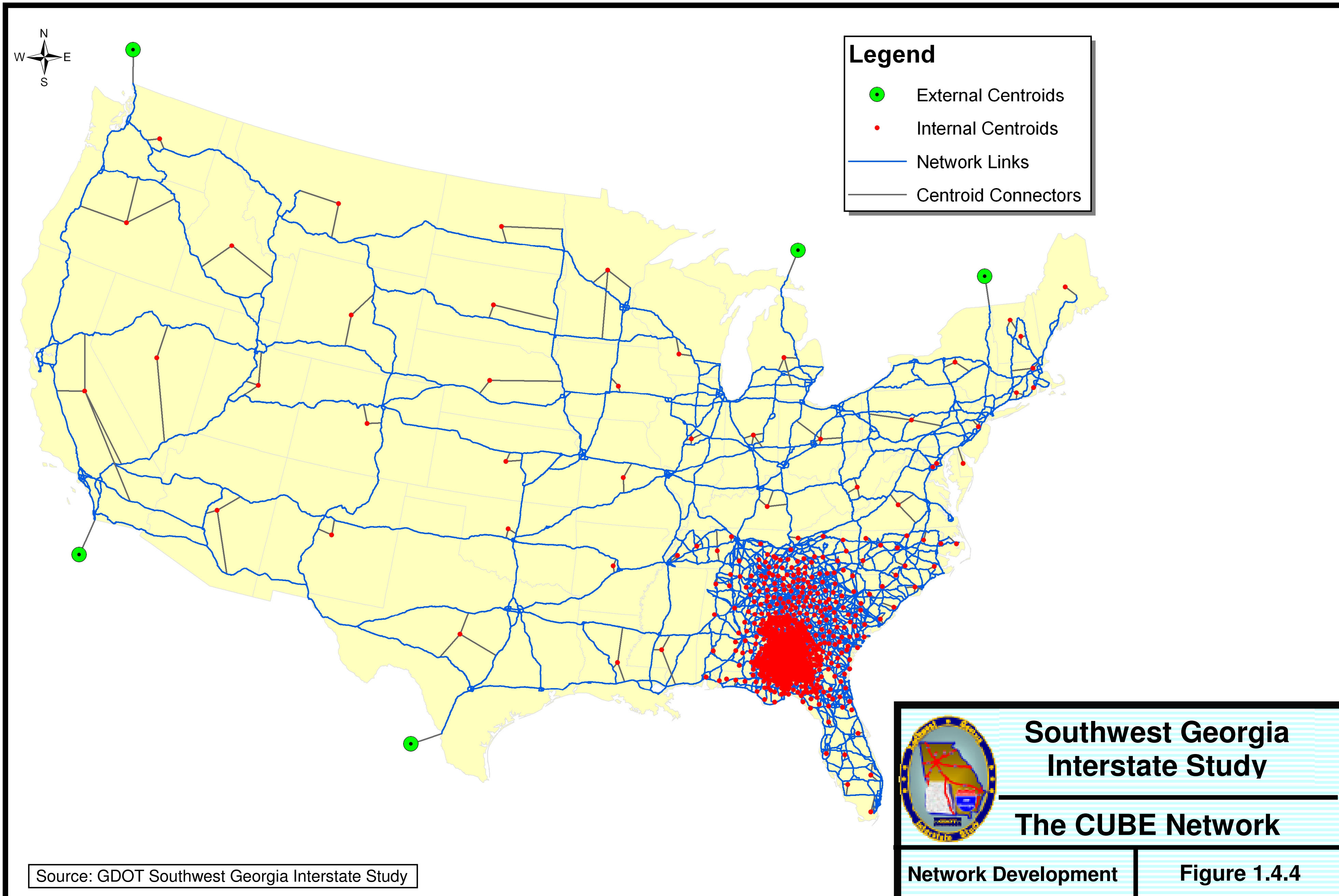
A centroid represents an abstract center for the social and economic activities of a TAZ. Trips to and from a TAZ are abstractly placed at a centroid point. A centroid point is created by using the X and Y coordinates for the center of each TAZ. The location of each centroid is then verified against the boundary of the TAZ, because the calculated centers for a few TAZs with irregular shape could be located outside the TAZs. The centroid points were created and validated in the ARCGIS with the TAZ identifier as well as the calculated X and Y coordinates attached. The centroid point layer is then recreated within CUBE as a node network and merged with the CUBE network created previously. The TAZ system includes 1,564 zones and 5 externals. Three of the externals are located in Canada and the other two are located in Mexico. Therefore, a total of 1,569 centroids were created within the base network.

Centroid connectors are needed to link the centroid to the rest of the highway network. A centroid connector is an aggregation of one or more small local streets or driveways that are not usually represented in the model network. It is an auxiliary connector facilitating travel between a centroid or TAZ and the rest of the network. The centroid connectors are special links in the network. They are not restrained by roadway capacity as the rest of the network links are, because each centroid connector may represent several access paths between the network and a centroid. Depending on the size of a particular TAZ, a centroid may require multiple centroid connectors to provide access to the network. The centroid connectors must connect to the network link at locations that reflect the approximate loading points where local streets and the highways meet. Thus, the point of loading for a centroid connector on a network link is determined by the configuration of existing local streets and driveways. The TIGER/Line centerline file was used in identifying the centroid connector's loading point or points on the network. It includes almost all local streets as well as the functional classified highways, thus providing a good guideline for placing the centroid connectors' loading points. Figure 1.4.3 shows the overlay of the TAZ system, centroids and their centroid connectors, as well as the TIGER/Line local streets. As shown in the figure, the loading point of a centroid connector, to some extent, reflects the configuration of actual local streets. The model network includes five external centroids: three in Canada, and two in Mexico. These external centroids are also served by the centroid connectors that represent border crossings. The final network for the Southwest Georgia Interstate model is shown in Figure 1.4.4.



Source: GDOT Southwest Georgia Interstate Study


N
W
E
S
Legend
Centroids
Centroid Connectors
Network Links
TIGER/Line Roads
Southwest Georgia Interstate Study
Network Centroids & Centroid Connectors
Network Development
Figure 1.4.3
Source: GDOT Southwest Georgia Interstate Study



Southwest Georgia Interstate Study

The CUBE Network

Network Development

Figure 1.4.4